Before the
Federal Communications Commission
Washington, D.C.
July 21, 2003

In the matter of	)	
	)	
Interference Immunity Performance Specifications for Radio Receivers	)	ET Docket No. 03-65
	)	
Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television	)	MM Docket No. 00-39

COMMENTS OF THE HARRIS CORPORATION

Harris Corporation ("Harris") is pleased to file Comments on the Commission's Notice of Inquiry "NOI" on Interference Immunity Performance Specifications for Radio Receivers and the Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television.

I Introduction and Summary

Harris is an international communications equipment company with five operating divisions that offer products and services in the microwave, broadcast, network support, secure tactical radio, and government communications systems markets. Harris is a pioneer in the development of digital television (DTV) broadcast technology and is in the forefront of the transition to digital television, supplying the majority of the DTV transmitters in the United States. Harris has a long and distinguished history in the development of innovative communications technology and has broad RF competence covering 100 kHz to 100 GHz systems.

Harris commends the Commission for undertaking a review of receiver performance in the context of the increasingly complex and congested interference environment faced by modern wireless communications systems. Harris supports the efforts to specify minimum requirement guidelines for radio receiver parameters such as the Bit Error Rate (BER) performance threshold and receiver co-channel and adjacent channel interference sensitivity. We feel, however, that these requirements should be imposed on a voluntary compliance basis, and should represent and incentive for equipment manufacturers to be innovative and to compete in the market place on performance and value. Experience has shown that standards that prove impractical are often difficult to change once they have gained acceptance. This is particularly acute in the case of broadcasting, where a single transmitter serves a great number of receivers. This situation would be less severe in Point to Point Fixed Microwave, where there the ratio of receivers to transmitters is much closer to unity.

Advances in modem and DSP technology have significantly improved the performance of digital receivers. Harris supports the principle of higher receiver sensitivity and improved selectivity over the use of higher transmitter power.

Harris supports the use of advanced antenna technologies that can mitigate the effects of interference and increase user density and frequency reuse.

Harris would support discussions on the relaxation of transmitter mask requirements – thus putting more stringent requirements on receiver selectivity.

Harris believes that receiver interference immunity is greatly dependent on the particular application, and that no one set of regulations is applicable to all instances. The NOI touches on all aspects of communications systems and, while this is commendable, we believe that a more detailed approach is required. When trying to formulate a set of specifications, the entire communications system – from transmitter through to the receiver – must be analyzed. For example, is this a broadcast system where a single or limited number of high power transmitters transmit to many receivers? Or is it a shared multi-user system? In the latter case, factors of channel access and control must be analyzed separately.

Harris is concerned about any unnecessary cost penalties resulting from overly restrictive regulatory processes imposed on equipment manufacturers, as these costs will ultimately be passed on to the public. We believe that a balance can be struck between more efficient spectrum usage and user cost, and that this process can best be served by allowing the market to establish receiver performance parameters.

II Specific Responses

(§2) Receiver Design Standards

Harris currently designs a large portion of our military equipment to meet military standards such as MIL-STD-188-164A and MIL-STD-188-165A. These standards provide the interference environment and required performance in those operating conditions. Harris maintains that these standards are sufficient and the FCC must not mandate ruling more stringent requirements than current DoD or government requirements. To do so would otherwise require a very comprehensive (and costly) transition plan. Also, in placing more requirements on receivers, the FCC must not abandon its efforts to provide limits on transmission devices, as the trend and desire for COTs equipment in military and Homeland Security scenarios continue to increase. Military equipment manufactures must be able to rely on levels of emission guaranteed by some means to avoid EMI.

(§8) Interference tolerance

Harris disagrees with the contention that "new digital technologies generally are inherently more robust, and resistant to interference, than analog systems." Where this may be true over a large part of the operating range of a digital communication link, it must be pointed out that system reliability is predicted on the assumption that a given fade margin can be maintained under adverse propagation and interference conditions. In order to meet predicted availability, digital systems must maintain levels of Threshold to Interference (T/I) protection that are, in some cases, more stringent than those for analog systems.

(§9) Interference Temperature Metric

We express some concern over how to express, measure and verify the interference temperature metric. In broad terms the concept is offers some utility, however, the interference spectrum in most applications is not white like white thermal noise. Given that spectrum use is dynamic and that typical adjacent channel interference is dominated by a few “strong” signals, we submit a great of care must be rendered to defining the concept of interference temperature so it is meaningful to actual environments envisioned by the FCC and easily verifiable/testable by manufacturers of equipment.

(§11) Legacy Issues

Legacy issues will persist for military equipment, such as SATCOM receivers, built on current US military standards such as MIL-STD-164A and MIL-STD-165A.

(§14) Receiver Interference Immunity Factors

When defining an interference temperature there are a number of factors must be considered. For example, a top-level issue when defining test cases is the spatial distribution of the sources and their frequencies relative to the spatial and frequency selectivity of the vulnerable receiver. Depending on the selectivity characteristics (i.e. spatial and frequency) of the vulnerable receiver or the multi-path environment a number of different interference temperatures are possible to define, and this freedom must not be left to a manufacturer. The absolute measurement of the interference temperature can vary depending on where (in the signal processing chain) and how the measurements are made. The parameter must always be referenced to a specific point in the signal processing chain. This measurement ambiguity is similar to the problem of stating a signal-noise ratio.

Also, we must consider how interference affects different classes of services and modulation types. If we attempt to specify with certainty that a specific amount of interference can always be tolerated, then we risk over designing equipment with a commensurate increase in cost for a majority of cases and applications where the cost/benefit trade is not favorable.

Some special designs that can be used include phased array technology or signal separation using spatial degrees of freedom. In either case we are adaptively steering nulls into interfering directions. But adaptive processors and multi-element antennas will increase cost in the units. Also, typically null steering is done for narrowband channels. But since receivers might now have the added burden of front-end pre-processing received signals for nulling, certainly operating power will increase. This would degrade the "on-time" of cordless equipment. However, this type of equipment is common to military systems where the cost/performance trade is favorable, and also system availability is enhanced even in hostile environments.

It is difficult to determine how coding might be effective in mitigating interference of a given strength since this is "many-to-one" mapping. Meaning there are many different ways one can achieve a certain temperature (i.e. a single strong emitter or a plurality of equal strength weak emitters). Hence again, care must be given to defining the concept and considering its implications for different services (i.e. mobile, SATCOM, wire line, fixed services, etc.).

(§15) Receiver Interference Environment

We believe that receiver specifications should be based on the environment in which a receiver is to operate. But also, consider the expected reliability/availability of the system and its application (i.e. emergency service/military vs. unlicensed consumer, urban/rural, etc.). This should help prevent over design from over generalization of requirements.

(§16) Receiver Performance Metrics

Typical information or decoded bit error rate (BER) is a meaningful metric for evaluation of communication systems. The specific BER that can be deemed acceptable, however, is highly dependent on the particular application. For example digitized voice can be considered intelligible at very high BER (say 10^-4); a data file concerning critical data, on the other hand, may require much more stringent performance (10^-9 or better). Hence, there is no one acceptable answer. Further, packet-based systems, depending on their protocol, may impose other metrics concerning packet receipt, again with varying levels of acceptability.

(§19) Coordination with other Standards Bodies

The FCC should work/consult with at least IEEE, ISO, ITU and the US DoD when developing this concept.

(§27) Satellite Services

In fixed satellite services antenna directionality must be considered since it directly impacts the reception of ambient signals. But also the spatial distribution and frequency distribution of interfering signals must be weighted in the design or analysis of any system.

It is impossible to provide a "one-size fits all" requirement, but we suggest as a good starting point in deriving requirements is the MIL-STD-164A/165A specifications. These specifications provide limits on interference that is tolerable along with performance specifications for a variety of digital modulation formats.

Also for fixed services, we must consider that LEO systems tend to slew over a certain field of regard. Often the slew is horizon to horizon, while GSO systems tend to remain in a relatively stable pointing position. However, for low inclination angles both LEO and GSO installations can encounter severe conditions. Hence, it might be advantageous to not only separate LEO and GSO applications, but also differentiate GSO applications based on inclination angle.

(§30) Fixed Terrestrial Services

The Commission should retain the current interference protection afforded to the Fixed Terrestrial services.

Harris feels very strongly that the current interference protection afforded to Fixed Terrestrial services should be maintained. As we will show later in these comments, the reliability of fixed microwave systems can be seriously degraded by the introduction of higher levels of interference, resulting in a reduction of service levels to many critical communication services depended upon by the public.

Harris also takes exception to the statement that fixed terrestrial receivers are exposed to a "lesser variation in operating environment conditions". On the contrary, fixed service microwave receivers, although not subjected to the same operating conditions as mobile systems, fixed systems must operate over continuously varying propagation conditions – that can, in some cases, exceed 50 dB of operating receive signal level variation. For this reason, we again stress the need to preserve the present interference protection enjoyed by fixed terrestrial services.

In response to the question of whether existing design features in Fixed Service Microwave receivers ensure measures for interference immunity, Harris would like to point out that the highly competitive nature of this business dictates that equipment manufacturers provide interference mitigation techniques as standard features. These techniques include:

- RF AGC, producing high receiver dynamic range – receivers so equipped are able to withstand higher levels of interfering signals without increased BER.
- High Receiver Selectivity for improved adjacent channel selectivity and image rejection

- Advanced coding techniques and Forward Error Correction (FEC) techniques.
- ATPC, while not strictly a receiver technique, often relies upon sophisticated receiver performance monitoring algorithms that facilitate real time BER measurements that are relayed to the transmitting end of the link to control transmitter output power. ATPC also reduces EIRP (and potential interference) during periods of normal propagation. EIRP is increased only when the link experiences "flat" fading.

III Fixed Service Interference Considerations

Harris would like to point out that, while applicable in some situations, the concept of permitting increased levels of interference into spectrum occupied by existing fixed service systems can have severe implications on the reliability performance of those systems. In the case of Point-Point Fixed Microwave systems, for example, increased levels of interference can result in reduced values of Threshold-to-Interference (T/I), with a corresponding reduction in system reliability. Point – Point FS Microwave systems are commonly designed to provide very high levels of availability – often 99.999% or better.

In digital systems the primary interference issue is that of threshold degradation, as performance is not usually affected by interference until the desired signal has faded to within 10 dB of its outage threshold[1]. Threshold degradation is produced by the

[1] Typically, 10^{-3} BER.

total power of the interfering signal falling within the victim receiver's noise bandwidth ("Baud-Rate Bandwidth"). Interference is quantified as the level of interference that will degrade the static (10^{-6} BER) or dynamic[2] (10^{-3} BER) threshold by 1 dB. T/I[3] has the advantage of taking into account the bit rate, modulation technique, coding gain and noise figure and the absolute level of permissible interference can be determined. The following table, extracted from TIA/EIA Bulletin TSB10-F illustrates commonly used T/I values :

4QAM, 4QPSK, OQPSK – 19.5 dB
16 QAM – 26.9 dB
64 QAM – 33.1 dB
128 QAM – 36.1 dB
256 QAM – 38.6 dB
512 QAM – 41.5 dB

These figures represent worst-case protection levels. As a result of powerful FEC techniques and superior modem design, typical equipment performance can be 2-3 dB better – that is, able to withstand 2-3 dB higher interference levels. The higher the modulation level, the higher the C/N that is required for any given BER threshold. Likewise, the higher the transmission capacity using the same modulation level, the higher the C/N required for any given BER level. Typically, in the absence of interference, the BER threshold will drop 3 dB if the transmission capacity is doubled for any given modulation level.

IV Conclusions

Harris supports the Commission's review of the interference immunity standards for radio receivers as these standards will facilitate improved access and operability of

[2] Also known as the Outage Threshold.
[3] TIA/EIA Telecommunications Systems Bulletin TSB10-F ***Interference Criteria for Microwave Systems***.

communications systems in an increasingly hostile interference environment. We do, however, convey the following caveats and concerns:

- We believe that receiver requirements should be voluntary, and should offer an opportunity for manufacturers to be innovative and to provide improved product value to the public.
- Any increase in receiver design complexity required to meet newly imposed regulations can result in increased manufacturing costs that will inevitably be passed on to the consumer.
- Harris would support minimum spectral efficiency utilization (modulation level) for different frequency bands.
- Harris supports the principle of higher receiver sensitivity and improved selectivity over the use of higher transmitter power.
- Transmit spectrum mask requirements should be more stringent for higher level modulation systems and less stringent for lower level modulation systems.
- Harris would support minimum BER, co-channel T/I and adjacent channel T/I specifications depending on frequency bands, capacity and modulation level.
- Increased interference temperature should not be allowed reduce the availability of Fixed Microwave Systems.

Finally, Harris strongly urges he Commission to retain the current interference protection afforded to the Fixed Terrestrial services.

Respectfully Submitted,

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HARRIS CORPORATION

Appendix A Application Interference Matrix

Application	Interference Temperature Considerations
Fixed Point-Point Microwave	For modern digital modulation systems, good engineering practice dictates that the interference shall not degrade the digital threshold of the victim receiver by more than 1 dB. The T/I value[4] varies depending on the modulation complexity: 4QPSK, OQPSK – 19.5 dB 16 QAM – 26.9 dB 64 QAM – 33.1 dB 128 QAM – 36.1 dB 256 QAM – 38.6 dB 512 QAM – 41.5 dB The absolute level of allowable interference can be determined by subtracting the T/I ratio from the static threshold of the digital receiver. Currently available Fixed Systems are typically 2-3 dB better than the figures shown here.
DTV Broadcasting	The 8VSB signal can handle up to 15 dB C/N, assuming White Gaussian Noise. In reality, increased SNR does degrade equalizer performance. If cases of non-Gaussian interference, the effect of the interference can be increased.

[4] From TIA TSB10-F ***Interference Criteria for Microwave Systems,*** June 1994